All About Space

CURIOSITY:

THE FIRST 12 MONTHS

By Jonathan O'Callaghan

This mosaic of Curiosity, with Mount Sharp in the background, was put together using 55 images taken by the Mars Hand Lens Imager (MAHLI)

Curiosity: the first 12 months

In August 2012, the most ambitious robotic vehicle ever devised landed on Mars on a mission to probe the Red Planet for signs of past and present habitability. We spoke to the team's deputy project scientist one year after about Curiosity's accomplishments at that point, and what they hoped it would be doing in the years that followed **Written by Jonathan O'Callaghan**

On 6 August 2012 the world watched in awe as a rover the size of a car descended to the surface of Mars under a rocket-powered contraption and touched down. Almost a decade in the making, the Mars Science Laboratory (MSL), better known as the Curiosity rover, has been a massive success story for NASA. Never before has such a large and complicated vehicle landed on another world.

In just 12 months after Curiosity went operational it made some tentative steps towards achieving its numerous goals, which include assessing Mars for signs of past and present habitability. NASA was careful to only take baby steps in its first 12 months, but in the following year Curiosity was pushed to the limits as it explored its surroundings and headed towards its ultimate goal, Mount Sharp (a mountain also known as Aeolis Mons), which rises 5.5 kilometres (3.4 miles) above the floor of Gale Crater and has layers of sediments that may hold clues about the Red Planet's history.

"When you land you have this incredible burst of adrenaline," Dr Joy Crisp, the deputy project scientist for the MSL mission, told **All About Space**. "But a lot of this first year involved [testing] of more and more [of our] capabilities. We needed to test things out on Mars before we went crazy, but now we are a lot more confident in the rover."

This was one of the first images Curiosity returned from Mars on 6 August 2012, showing the rover's shadow in the foreground and Mount Sharp towering in the background

That's not to belittle any of the accomplishments of Curiosity however. After only a few tentative steps, the rover found evidence of a watery past on Mars and returned stunning high-resolution images from the surface.

The first piece of evidence of Mars' wet past that was discovered by Curiosity came from "conglomerate rock with rounded pebbles in it," Dr Crisp explained. "When we looked at those pebbles and saw how rounded they were, that led the science team to be able to figure out how deep the water had to have been and how fast it was flowing. They were able to determine that those rocks were deposited from a stream."

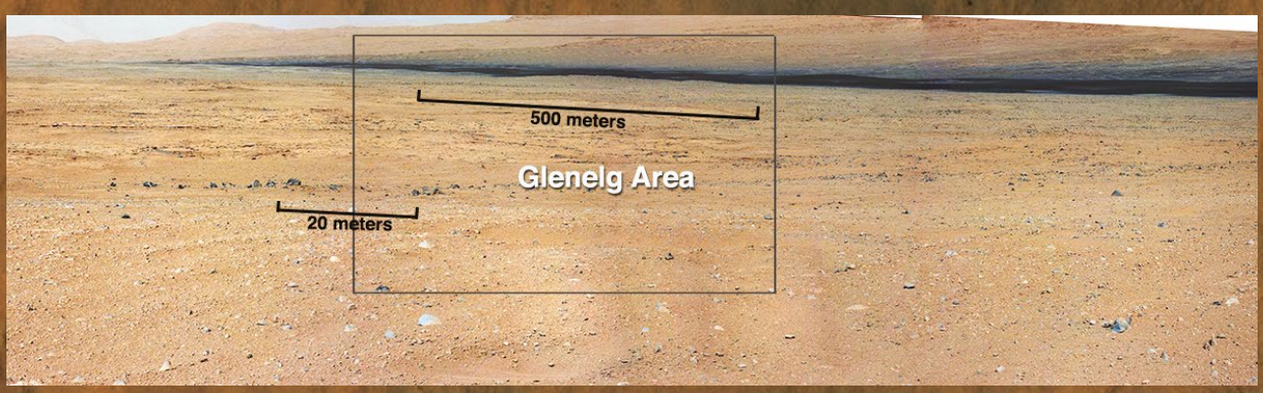
With groundbreaking discoveries like this already being made, we expect great things from Curiosity in its future as the team became more confident in its abilities.

In the year after the rover landed, the MSL team at NASA's Jet Propulsion Laboratory in California made great strides in their operations to make sure they get the most out of the mission. "We try to come up with better ways to do operations, so we've had to make changes along the way to make the whole operations

A year on Mars

19 August 2012
First laser shot
During its first two weeks Curiosity tests several of its instruments, including the firing of its ChemCam laser for the first time on 19 August 2012 on a rock called Coronation (or N165).

6 August 2012
Bradbury landing site
Using the revolutionary Sky Crane mechanism, Curiosity successfully lands on Mars 2.4km (1.5mi) from the centre of its wide target area.

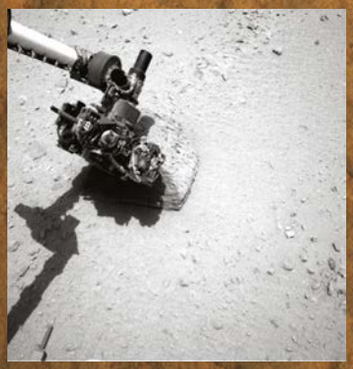


29 August 2012
Driving begins
Curiosity begins its first drive on 29 August to an area called Glenelg about 400m (1,300ft) east of its landing site.

The MSL team at NASA's Jet Propulsion Laboratory celebrate as Curiosity successfully lands on Mars

timeline go faster," said Dr Crisp. "We started out working on Mars time [one Martian day is 37 minutes longer than an Earth day], taking about 16 or 17 hours preparing the rover's commands for the next day, and we've gotten that down to 11 hours now, so we can work more normal hours."

Considering the complexity of the mission, it's remarkable that things went so smoothly in the first 12 months, barring one mishap. "It's performed very well," agreed Dr Crisp, "but we did have one hiccup where one side of the computer had an issue, so we had to switch to the other side, but overall everything has been functioning okay. It's a very, very complicated beast and it takes a lot of effort [for] everybody to understand that complexity and be able to plan what the rover should do each day."



19 September 2012
First contact
Curiosity uses the Mars Hand Lens Imager (MAHLI) and Alpha Particle X-Ray Spectrometer (APXS) to touch and study a rock, named Jake Matijevic, for the first time.

7 October 2012
First scoop
Curiosity collects its first scoop of Martian soil at a location known as Rocknest to be analysed by the SAM (Sample Analysis at Mars) and CheMin (Chemistry and Mineralogy) instruments.

8 February 2013
First hole drilled
Curiosity uses its drill at the end of its robotic arm for the first time on a patch of flat rock called John Klein, making a hole 2cm (0.8in) deep.

4 April 2013
Curiosity goes quiet
From 4 April to 1 May Curiosity operates autonomously on the Martian surface due to Mars being on the opposite side of the Sun from Earth, making communications difficult.

5 June 2013
Journey to Mount Sharp
NASA announces that Curiosity is getting ready to begin its year-long trip from Glenelg to the base of Mount Sharp, a journey of over 8km (5mi).

27 September 2012
Streambed found
Images of what appears to be an ancient streambed on Mars are returned by Curiosity. NASA confirms the findings several months later.

3 December 2012
Water discovered
Evidence of water molecules on Mars, in addition to sulphur and chlorine, is discovered by Curiosity as it performs its first extensive soil analysis.

To Mount Sharp

"We needed to test things out on Mars before we went crazy, but now we're a lot more confident in the rover"

Dr Joy Crisp, MSL's deputy project scientist

As mentioned earlier, the primary objective of Curiosity's mission is to ascend Mount Sharp and study the mountain's various sedimentary layers. However, as Curiosity's projected landing site was within an area 19 kilometres by 7 kilometres (12 miles by 4 miles), NASA was unsure where exactly the rover would land. Ultimately it touched down just a few kilometres from the centre of this area, near a region of particular interest known as Glenelg. So, rather than rushing straight to Mount Sharp, NASA made the decision to explore the flat plain of Gale Crater first, and then take another look at Glenelg on its way back, if possible.

"Looking at where we landed from the orbiter images we realised it would make sense to first go over to Glenelg and check out these different rocks that we could see before heading over to Mount Sharp," explained Dr Crisp. But while the lifetime of the rover was set at a lowest estimate of two years, "if it's anything like Spirit and Opportunity this rover may last much longer than two Earth years," which gives Curiosity plenty of time to study Mount Sharp. In fact, NASA extended the operational lifetime of the mission indefinitely, giving the MSL team funding to continue driving the rover until it stops working, which could be several decades from now.

Aside from observing pebbles in an ancient streambed, indicative of a wet past on Mars, Curiosity also tested out its other instruments to ensure they were working normally ahead of some planned hardcore science for the rover. "We're looking for past environments that could have been suitable for life," explained Dr Crisp, "and liquid water is key for life as we know it. So getting over to Yellowknife Bay [a Martian outcrop in the Glenelg area] and drilling into sedimentary rock and discovering abundant clay mineral, which has a lot of bound water in it that can only form in the presence of liquid water, was a major find."

Not all of Curiosity's instruments had returned data with such a high level of interest at that point, though, but of most importance to Dr Crisp was ensuring that "the instruments were working well." One

Curiosity in numbers

The facts and figures about NASA's flagship Mars rover

899 kilograms

Mass of the Curiosity rover

$2.5 billion

Total cost of the Mars Science Laboratory mission

14 minutes

Time it takes to send a command to Curiosity

55 years

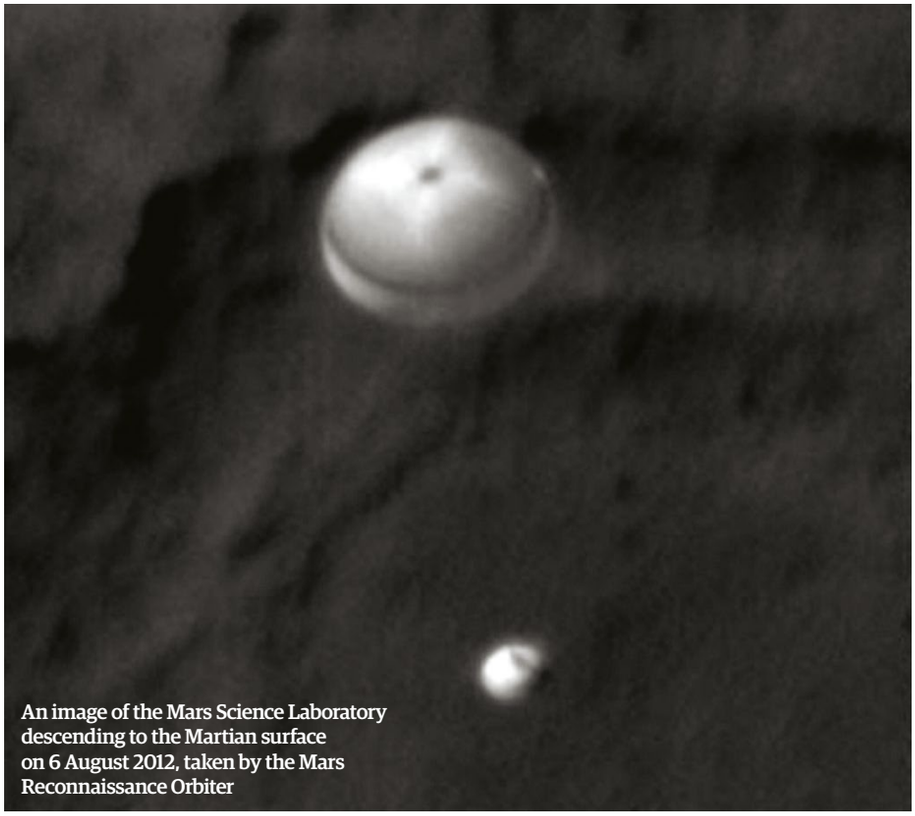
Upper estimate of Curiosity's possible operating lifetime

10

Number of scientific instruments on board Curiosity

5 *Curiosity is about 5 times larger than its predecessors Spirit and Opportunity*

668 *Number of Martian days (sols), or 687 Earth days, the primary mission lasted*



An image of the Mars Science Laboratory descending to the Martian surface on 6 August 2012, taken by the Mars Reconnaissance Orbiter

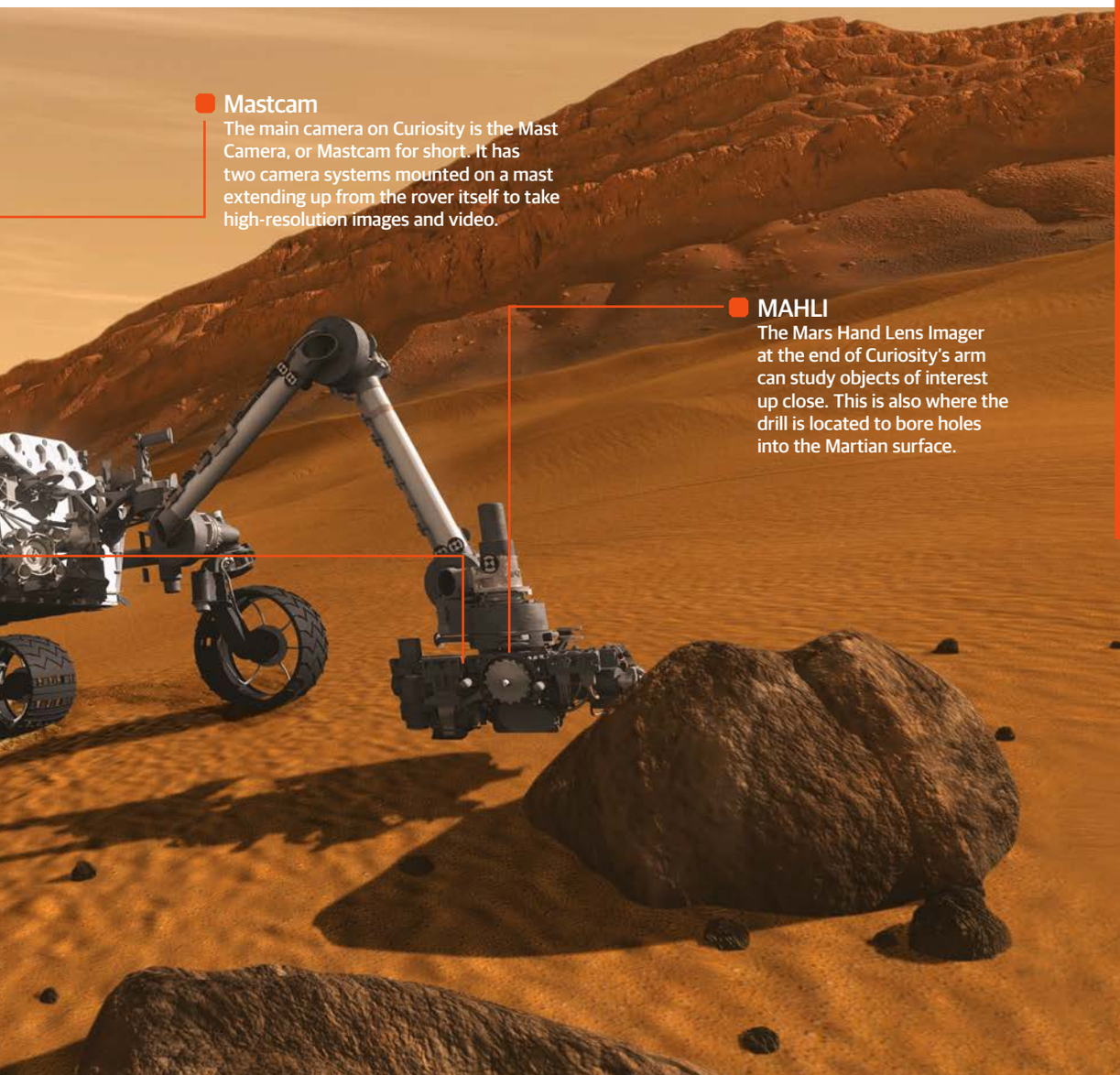
Five key instruments on Curiosity

of the most important instruments on the Curiosity rover is SAM (Sample Analysis at Mars), a suite of instruments comprising over half of the rover's scientific payload that can scoop up soil samples and analyse them in an on-board laboratory. "We sent the SAM instrument to look for organic compounds," said Dr Crisp, "but we knew it was going to be like looking for a needle in a haystack. It's not easy to find organic compounds preserved in ancient rocks even on Earth, so we didn't really expect to hit it on the first try." SAM, however, was expected to be one of Curiosity's most valuable assets when it comes to studying the sedimentary deposits on Mount Sharp.

With the first year behind them, the MSL team were eager to really get the wheels rolling and make use of Curiosity as best they could. According to Dr Crisp, in the next 12 months "we will be driving a lot further than we've done so far, heading towards Mount Sharp, so we don't know what exactly we'll encounter or what we'll see from our cameras on the surface. We can see from orbit that we might want to stop a handful of times on our way to Mount Sharp but we don't want to get bogged down unless there's something really amazing that we discover on the way. So [in the next 12 months] we'll be doing a lot of driving, and if you've seen the pictures of Mount Sharp with the layering it looks really fascinating. So I think that will be a magnetic pole for our team to psychologically want to keep going, because as we drive the detail of what we can see in those hills is going to get more and more interesting," she added.

While Curiosity's predecessors Spirit and Opportunity (neither of which are currently operational) have travelled tens of kilometres on the surface, never before has a rover attempted to scale a mountain on Mars in the way Curiosity did. But, as Dr Crisp explained, the team believes the rover will have no problems making its way to a higher altitude. "The wind should not be a problem," she said, "and it'll be interesting for the meteorological instrument to measure that. The steepness we believe will also be okay, based on studying the 3D models we have from our orbiter data. When we actually get there and see the terrain up close our 3D models will improve and we may have to adjust our routes based on that newer data as well as finding out how much the rover slips on different kinds of rock."

So, with the most exciting part of Curiosity's mission yet to happen, Dr Crisp highlighted a "combination of new things" that would be of most interest to both scientists and the public alike in the coming year. "I'm hoping that we're going to see some new rock types and new landforms that tell us about other things that went on in the past on Mars," she said. And with the public clamouring for more astounding science and incredible imagery from Curiosity, the rover's mission could only get better and better as the team becomes more confident in their operation of one of the greatest and most ambitious space exploration missions of all time.



The goals

Has Curiosity acomplished what it set out to do?

Did it demonstrate the ability to land a large rover on Mars?

Yes. The car-sized Curiosity rover successfully landed in Gale Crater by the foot of Mount Sharp.

Did it reach Mount Sharp?

Yes. On 11 September 2014 the rover arrived at the foot of the mountain. It then proceeded to travel up and collect rock samples.

Did it discover new rock types on Mars?

Yes. After drilling into sedimentary rock and analysing the samples, the rover discovered tridymite, a silica mineral often occuring in volcanic rocks, which wasn't thought to be present on Mars.

Did they determine the climate and geology of its landing area? Did it confirm ancient lakes?

Yes. Over six years the rover, using its Sample Analysis at Mars (SAM), found that Mars has seasonal variations in its levels of methane, higher in warmer weather and seeing a drop in colder periods. It also found evidence in Gale Crater to suggest that billions of years ago Mars was home to lakes.

Did it determine the habitability of the planet?

Yes. Curiosity discovered that Mars' radiation levels were much higher than previously thought, beyond NASA's limit for astronauts. For humans to live on the planet, scientists would need to design habitats to accomodate the high radiation levels.